Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11445, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11445
EGU General Assembly 2008

On stress rotations in fault damage zones

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The rotation of stress around fault zones is a necessary precursor to allow high pore fluid pressure weakening of faults without incurring hydrofracturing. We have previously presented a model that quatitatively describes how stress may be modified around a fault developed in low porosity crystalline rocks (Faulkner et al., 2006). The model is based on field observations of microfracture damage surrounding a large fault and experimental measurements of the elastic property changes in crystalline rocks as microfracture damage accumulates. The model assumes elastic isotropy and shows that the greatest principal stress can be significantly rotated in the fracture damage zone. Accompanying the rotation are increases in the mean stress and a reduction in the differential stress.

We re-analyze the model we previously used to determine the key parameters and their sensitivity in the modification of the stress field. Changes in the Poisson's ratio are found to dominate the stress changes surrounding a fault. Variations in Young's modulus have a minor effect on stress rotation, mean stress or differential stress. We also use new experimental data on the elastic properties of basalt to compare stress modification around fault in this material with our previous results.

In our isotropic model, the Poisson's ratio (and Young's modulus) will be equal in all directions. But in the more general case of anisotropy, the appropriate value of Poisson's ratio in the direction of the applied greatest principal stress is critical. Field measurements of microfracture orientation we made surrounding strike-slip faults developed in granodiorite in northern Chile show most microfractures are oriented with their poles in a sub-horizontal direction, with many at a high angle to the fault plane. If these cracks are interpreted as mode I cracks, then the Poisson's ratio in a direction at a high angle to the fault plane should correspond well with those used in our isotropic model. The work highlights the need for experimental measurements of elastic anisotropy that develops in brittle rocks approaching failure.